Noteworthy anatomical and physiological researches.

Carbon dioxide and living protoplasm.

The question as to the influence of CO_2 on the protoplasm has received much investigation but is not accurately determined. Giuseppe Lopriore, before giving an account of his reinvestigation of the question,[1] summarizes the previous knowledge as follows:

The influence of CO_2 upon the protoplasm of green plants is different from that upon the colorless protoplasm of the yeasts and bacteria. The latter are capable, in comparison with the green plants, of enduring a very large amount of CO_2, or even of living in almost pure CO_2. This relation, however, differs with different species of bacteria. Some thrive almost as well in pure CO_2 as in air; others show diminished growth; while a third group will only develop when the cultures are kept warm in the incubator. While CO_2 at ordinary pressure is not fatal to bacteria, at a higher pressure it may be.

The yeasts behave differently—even oppositely—according to the species. According to Brefeld yeast may grow in CO_2 which contains as little oxygen as $\frac{1}{6000}$ of its volume, which may therefore be considered almost pure. According to Foth, on the contrary, CO_2 exercises a strongly retarding influence upon the power of multiplication of yeast.

The relation of CO_2 to green plants is inferred from the experiments upon different vital phenomena which here may best be considered singly.

As to the germination of seeds, this does not occur in pure CO_2, which appears to kill embryos of swollen seeds. If the seeds are dry they resist its action as well as in air. In an atmosphere containing 50% CO_2 seeds cannot germinate, but viability is not lost for they do germinate upon being transferred to air. Seedlings which can stand this gas mixture when exposed to sunlight die, on the contrary, in an atmosphere containing only 8% CO_2 when they are kept in darkness.

[1] Ueber die Einwirkung der Kohlensäure auf das Protoplasma der lebende Pflanzenzelle. Pringsh. Jahrb. f. wiss. Bot. **28:** 531–626. *pl. 2. figs. 3.* 1895.

As to the influence of CO_2 upon carbon-assimilation and the excretion of oxygen, most researches show that a small amount of CO_2 (4–10%) increases carbon-assimilation, while a higher percentage diminishes it, or even works injury to the plant. But carbon-assimilation depends on the function of chlorophyll, and this points to the fact that if the young plants are not provided with chlorophyll they could not bear this percentage of CO_2; for according to Boehm, the formation of chlorophyll is retarded in air with 2% and suppressed in air with 20% CO_2.

As to the influence upon the phenomena of movements, susceptibility to these does not entirely disappear even after a long stay (6–12 hours) in CO_2. So long as the plant remains alive irritability returns when the plants are transferred again to atmospheric air. In the sleep-movements of Oxalis leaves an accommodation to the CO_2-atmosphere is even possible. The plasma-streaming shows a like relation. Stopped by CO_2, it begins again after some time if the CO_2 is replaced by air. The motility of protoplasm is not destroyed unless the CO_2 acts too long.

Lopriore undertook to re-investigate the action of pure CO_2 and O in different proportions upon the vital activity of protoplasm without chlorophyll, and especially upon the growth of living plant cells. In the preparation of gases special precautions were taken to have them pure. The CO_2 was prepared by the costly process of heating potassic bicarbonate, which yields under the best conditions only half its gas—a process first used in physiological work by Schloesing and Laurent. The impossibility of obtaining CO_2 free from vapor of HCl when this acid is used to liberate the gas from marble determined the author to avoid this common process. The difficulty of refilling Kipp's apparatus on account of the gypsum formed when H_2SO_4 is used, although it yields extraordinarily pure CO_2, deterred him from using Bunsen's method. The potassic bicarbonate used must be chemically pure and specially tested as to its freedom from ammoniates and nitrates.

The oxygen was prepared by heating the purest potassic chlorate in a glass retort with the usual precautions. Hydrogen was at first prepared in a Kipp's apparatus from zinc and sulfuric acid and washed through plumbic acetate and KOH, but later compressed H was purchased and purified.

Five glass gasometers of 25^l capacity each were used, after being carefully calibrated for each half liter. Three of these were used for pure gases and two for mixtures. It was found very difficult to secure a definite mixture, say of two parts CO_2 and one part O, and impossible to maintain it for any length of time on account of the unequal absorption by the water. This led to the employment of paraffin oil as a protection to the water. Eudiometric analysis showed that during twenty-four hours (the usual period for which a gasometer was used) no considerable alteration then occurred in the percentage composition of the mixtures. Gas analyses were made at frequent intervals to check errors.

The gas chambers in which objects were observed were of the form used by Kny, round shallow brass boxes 38×18^{mm} or 30×12^{mm} with entrance and exit tubes at the side, having the bottom of thick glass and the top a metal ring, with coverglass in the center, which screws on air-tight by means of an intervening washer. The object could then be placed in a hanging water drop on the under side of the coverglass.

After discussing the sources of error, the author presents a detailed account of his experiments, only the results of which can be here summarized from his own words.

1. Pure CO_2, if its action does not exceed a certain time, variable in different cases, has a retarding influence upon the vital phenomena, but not a permanently injurious one.

2. The retarding action of the CO_2 is not negative, due to the absence of oxygen, but a specific characteristic.

3. The CO_2 in many cases probably increases, either directly or indirectly, the extensibility of still growing membranes. In many other cases when the extensibility is not sufficient it brings about a rupture of the membrane of living cells.

4. A small amount of CO_2 (1–10 per cent.) accelerates the growth but does not raise the turgor-pressure of pollen-tubes which have been accelerated in growth. The turgor increases gradually if the pollen-tubes are, after a short exposure to CO_2, again exposed to atmospheric air.

5. Different cells of a plant are sensitive to CO_2 in different degrees.

6. Living plant cells may become inured to the disturbing action of CO_2. The plasma is also capable of a certain degree of accommodation.—R.